Attachment 3

Peer Review Letters

WINCHESTER SOUTH PROJECT

Environmental Impact Statement

WHITEHAVEN COAL

Resource Strategies

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DATE: 28 June 2021

TO: Whitehaven WS Pty Limited
PO Box 638
Newcastle NSW 2300

FROM: Dr Noel Merrick

RE: Winchester South Project – Groundwater Peer Review

YOUR REF: PO WS100138/1

OUR REF: HA2021/7

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1. Introduction

This report provides a peer review of the groundwater impact assessment (GIA) and associated modelling for the Winchester South Project (the Project). The GIA has been prepared by SLR Consulting Australia Pty Ltd (SLR) under the project management of Resource Strategies Pty Ltd (RS), for the client Whitehaven WS Pty Ltd - a subsidiary of Whitehaven Coal Limited (WHC). The Project is a metallurgical open cut coal mine within the Bowen Basin, Queensland, about 30 km south-east of Moranbah and due west of the recently-approved Olive Downs South Coking Coal Project.

The main elements of the Project that are relevant to groundwater assessment are:

- Life of mine is approximately 30 years.
- Six separate open cut pits with four final voids.
- Mining of the Leichhardt and Upper Vermont seams in the Rangal Coal Measures.
- Many surrounding coal mines and one coal seam gas operation.

Mining is to run approximately parallel to Isaac River, at nearest distances of 2-4 km, but the alluvium of the Isaac River will not be intercepted.

2. Documentation

The review is based on the following report:

1. SLR, 2021, Winchester South Project EIS Groundwater Impact Assessment. Report 620.13245.10000-R01-v3.4 prepared for Whitehaven Coal Limited, May 2021. 138p (main) + 5 Appendices.

Groundwater modelling details are in Appendix B of Document #1:

2. SLR, 2021, Groundwater Modelling Technical Report. Appendix B, Report 620.13245-R02-v6.0, 20 May 2021. 79p + 6 Appendices.

Document #1 has the following major sections:

1. Introduction
2. Legislative Requirements and Relevant Guidelines
3. Existing Conditions
4. Geology
5. Hydrogeology
6. Groundwater Simulation Model
7. Impacts on Groundwater Resources
8. Management and Mitigation Measures
9. Limitations
10. References

The Appendices are:

A1. Geophysical Surveys
A2. Groundwater Monitoring Network
A3. Groundwater Quality
A4. Olive Downs Project, Moorvale South Project and Winchester South Project Bore Census Surveys
B. Modelling Technical Report

Document #2 is structured as follows:

1. Introduction
2. Model Construction and Development
3. Predictive Modelling
4. Recovery Model
5. Sensitivity and Uncertainty analysis
6. Limitations and Recommendations
7. Conclusions
8. References.

The Appendices are:

A. Calibration Bore Hydrographs
B. Calibration Residuals
C. Hydraulic Zone Distributions
D. Drawdown Progression over Life of the Project
E. Parameter Distributions
F. Sensitivity Derivatives

3. Review Methodology

While there are no standard procedures for peer reviews of entire groundwater assessments, there are two accepted guides to the review of groundwater models: the Murray-Darling Basin Commission (**MDBC**) Groundwater Flow Modelling Guideline[1], issued in 2001, and guidelines issued by the National Water Commission (**NWC**) in June 2012 (Barnett *et al.*, 2012[2]). Both guides also offer techniques for reviewing the non-modelling components of a groundwater impact assessment.

The NWC national guidelines were built upon the original MDBC guide, with substantial consistency in the model conceptualisation, design, construction and calibration principles, and the performance and review criteria, although there are differences in details.

The NWC guide promotes the concept of "model confidence level", which is defined using a number of criteria that relate to data availability, calibration, and prediction scenarios. The NWC guide is almost silent on coal mine modelling and offers no direction on best practice methodology for such applications. There is, however, an expectation of more effort in uncertainty analysis, although the

[1] MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides

[2] Barnett, B, Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report 82, National Water Commission, Canberra.

guide is not prescriptive as to which methodology should be adopted.

Guidelines on uncertainty analysis for groundwater models were issued by the Independent Expert Scientific Committee (**IESC**) on Coal Seam Gas and Large Coal Mining Development in February 2018 in draft form and finalised in December 2018[3].

The groundwater guides include useful checklists for peer review. This groundwater impact assessment has been reviewed according to the 36-question Model Appraisal checklist[4] in MDBC (2001). This checklist has questions on (1) The Report; (2) Data Analysis; (3) Conceptualisation; (4) Model Design; (5) Calibration; (6) Verification; (7) Prediction; (8) Sensitivity Analysis; and (9) Uncertainty Analysis. Non-modelling components of the groundwater impact assessment are addressed by the first three sections of the checklist.

This review has been conducted progressively, with involvement of the peer reviewer at all stages of model development and application. The interaction was conducted through:

- Review of progressive revisions of report text.
- Reconciliation of review comments in two phases.
- One videoconference with WHC, RS and SLR.
- Several phone discussions with RS and SLR.

Previous verbal and written review comments have been addressed satisfactorily, the latest review comments being advised on 21 October 2020.

A detailed assessment has been made in terms of the peer review checklists in **Table 1** and **Table 2**. **Table 1** addresses reporting, data analysis, conceptualisation and model design. **Table 2** addresses calibration, verification, prediction, sensitivity analysis and uncertainty analysis. Supplementary comments are offered in the following sections.

4. Report Matters

The GIA report is a high-quality document of about 150 pages length, with an additional 1,165 pages in four Appendices that contain information on field investigations, monitoring bore details, groundwater quality, and bore census details. A separate numerical modelling technical report is additional. The main report is well-structured, well-written and the graphics are of very high quality and designed to ease understanding by readers. The report serves well as a standalone document, with no undue dependence on earlier work. However, the report is missing an Executive Summary and a Conclusion section for a summary of the GIA findings. This summation could be in the over-arching EIS main report not seen by this reviewer.

The technical modelling report adds a further 250 pages inclusive of six Appendices. Similarly, it is structured appropriately with sufficient detail and disclosure of methods and results. Document #2 is not intended as a standalone report because some of the key results are reported only in the main GIA report (e.g. post-closure groundwater levels).

Previous review comments on factual and editorial matters, on both reports, have been considered by SLR and have been accommodated satisfactorily in revisions of the reports.

The groundwater assessment objectives are stated clearly in the GIA at the outset (Section 1.3) in the form of 14 dot points. Although the objectives are met, there is no Conclusion section that addresses those objectives in summary form.

The modelling objectives are itemised in Section 6.1.1 of the main report in the form of three dot points:

[3] Middlemis H and Peeters LJM (2018) *Uncertainty analysis—Guidance for groundwater modelling within a risk management framework*. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2018.

[4] The NWC guidelines include a more detailed checklist with yes/no answers but without the graded assessments of the MDBC checklist, which this reviewer regards as more informative for readers.

- *“assess the groundwater inflow to the mine workings as a function of mine position and timing;*
- *simulate and predict the extent and area of influence of dewatering and the level and rate of drawdown at specific locations; and*
- *identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary.”*

The model has been constructed and applied to address these objectives satisfactorily.

Overall, there are no significant matters of concern in the reports as to structure or depth of coverage, and there is a clear focus on regulatory requirements.

5. Data Matters

The geology, though complex, is reasonably well known. It is illustrated by maps of outcropping geology, solid geology, structural faults and cross-sections. Structure contours and thickness maps are provided for alluvium/regolith, Triassic units, Leichhardt Seam and Upper Vermont Seam.

Considerable effort has been put into resolving different interpretations of alluvial extent associated with the Isaac River, included geophysical surveys (AgTEM and DC resistivity), slope break analysis, CSIRO regolith inference, LiDAR and bore logs.

The Project has a recently-installed (2019) network of 14 groundwater monitoring sites including two multi-sensor vibrating wire piezometer (VWP) holes. This supplements an extensive regional network associated with neighbouring mines consisting of 44 listed standpipes and five VWP bores. However, calibration hydrographs are reported for a larger total set of 98 bores.

Cause-and-effect analysis of groundwater hydrographs has been presented separately for bores in alluvium, regolith, Rewan Group and Permian strata, compared in each case with rainfall residual mass to infer potential relationships with infiltrating rain water. The earliest measurements in the region date from 2011. The Isaac River stream hydrograph is compared with near-river bore hydrographs to infer groundwater / surface water connectivity, demonstrating that the Isaac River generally has a “losing” status.

Groundwater flow directions can be inferred from groundwater head contours for alluvium (Figure 5-8, Document #1) and the Rangal Coal Measures (Figure 5-12, Document #1).

Hydraulic conductivity estimates for modelling are informed by significant investigations for other mining projects and by local slug tests, core laboratory measurements and two packer tests into known faults. The packer tests found hydraulic conductivity values in the faulted material of the order of 10^{-4} to 10^{-3} m/day. There is now a large database of hydraulic conductivity values in this part of the Bowen Basin. Overall, there is a clear expression of decrease with depth (Figures 2-8 and 2-9 in Document #2).

A thorough analysis is presented for groundwater quality signatures, primarily using Piper diagrams.

A clear and defensible description of hydrogeological conceptualisation is promoted in Section 5.7 of Document #1, illustrated by schematics for pre-mining, during-mining and post-mining conditions in cross-section.

6. Model Matters

The Winchester South groundwater model has been based on the well-received groundwater model for the recently-approved Olive Downs South Coking Coal Project, to the immediate east of the Project. An extension of the model to the north-west towards Moranbah was required to accommodate the Caval Ridge Open Cut and move boundary conditions 10-15 km farther away to prevent edge effects on model predictions.

The reviewer concurs with the entire modelling methodology described in Document #2 and recognises it as "state-of-art".

Key features of the modelling approach are:

- MODFLOW-USG plus AlgoMesh software platform for better mass balance and better spatial resolution;
- conventional PEST calibration for steady-state and transient conditions;
- application of an identifiability procedure during the calibration process to replace sensitivity analysis by perturbation, in which many more model properties can be included, and relative sensitivities are produced as a matter of course; the downside is an absence of reporting on calibration performance (if a sensitive parameter were varied); the considered parameters are horizontal hydraulic conductivity, hydraulic conductivity anisotropy, specific yield and diffuse recharge;
- assessment of the sensitivity of the magnitude of key model predicted outputs by a novel procedure for sensitivity derivatives; the considered outputs are pit inflows, alluvial take, alluvial drawdown and area of drawdown impact; and
- a *monte carlo* style rigorous procedure for uncertainty analysis.

The model extent is necessarily large, being about 50-65 km in an east-west direction and about 70 km in a north-south direction. Given the large area and 14 layers, a minimum cell dimension of 50 m, and incorporation of many neighbouring open cut and underground mines, a total cell count of less than one million (about 790,000) is very efficient. Separate layers are designated for the two target coal seams (Leichhardt and Upper Vermont), while the deeper coal seams relevant to coal seam gas activities are aggregated into two thick zones representing the Fort Cooper and Moranbah Coal Measures. Many structural faults are included in the model as zones of finer discretisation with properties separate from the host materials. Conceptualisation of faults as barriers was supported during PEST calibration which allowed faults to range from a strong barrier to a conduit, although their identifiability proved subsequently to be low.

In terms of model confidence level classifications, Document #1 states:

> *"...The numerical groundwater model for the Project would be classified as a Confidence Level 2 (Class 2) groundwater model, with the following key indicators (based on Table 2-1 of Barnett et al., 2012):*
>
> - *Groundwater head observations and bore logs are available and with a reasonable spatial coverage around the site and regionally.*
> - *Seasonal fluctuations are not accurately replicated in all parts of the model domain (Level 2).*
> - *SRMS error and other calibration statistics are acceptable (Level 3).*
> - *Suggested model use is for prediction of impacts of proposed developments in medium value aquifers (Level 2)."*

Although Class 2 is appropriate, all models are in fact mixtures of Class 1, Class 2 and Class 3. The relative proportions of the different classes could have been established by annotating the classification table of attributes in the IESC Explanatory Note on Uncertainty Analysis.

Calibration performance is generally good in most areas of the model, based on about 19,000 measurements of groundwater level at 174 sites, with overall statistics of 5.2 %RMS and 5.8 mRMS. Scattergrams are generally linear over about 100 m range in head values.

The primary predictive results are presented in Document #1 and Document #2 as maps of maximum incremental drawdown (due to the Project alone) for regolith, Leichhardt Seam and Vermont Seam, and as maps of maximum cumulative drawdown (due to all mines) for alluvium, regolith, Leichhardt Seam and Vermont Seam.

A comprehensive IESC-compliant Type-3 uncertainty analysis has been undertaken by means of a *monte carlo* technique, using 257 alternative calibrated realisations out of a trial set of 1,400 selections. The parameters subject to variation were horizontal hydraulic conductivity, hydraulic conductivity anisotropy, specific yield, specific storage and diffuse recharge. The assumed standard deviations were either 0.5 or 1.0 (log10 space), the higher value being applied only to horizontal hydraulic conductivity. The accepted 18% of models achieved better than 6 %RMS, which is 15% higher than the base case calibration performance. Proof of convergence, as encouraged by the IESC Explanatory Note on Uncertainty Analysis, is offered for total pit inflow, alluvial take, maximum drawdown in alluvium, Layer 1 area in excess of 1 m drawdown and Layer 7 area in excess of 1 m drawdown.

The base case model has ~25% less pit inflow than the 50th percentile of the 257 realisations. This could be due to the imposition of many constraints on the selection of parameters for a realisation. In other words, parameters cannot be chosen with full freedom from their designated distributions. See Tables 5-1 to 5-4 in Document #2.

The temporal uncertainty results are presented in Document #2 in Figure 5-5 as 5th, 50th and 90th percentiles for progressive pit inflow. The spatial uncertainty results are presented in Document #2 in Figures 5-8 and 5-9 as 10%, 50% and 90% probabilities of exceeding 1 m drawdown in Layers 1 and 7 (Vermont Seam).

Recovery in the presence of a final void has been modelled in two steps using initially the "high-K" lake approach, and subsequently time-varying constant heads provided from the surface water model. The reviewer endorses deference to surface water modelling for a more robust analysis of final void behaviour than is readily achievable in a groundwater model. The freeboards in the four final voids range from 50 m to 79 m, giving confidence that they will remain as perpetual groundwater sinks.

7. Conclusion

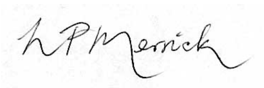
The reviewer is of the opinion that the documented groundwater assessment is best practice and concludes that the model is *fit for purpose*, where the purpose is defined by the objectives listed in Document #1:

- *"Review relevant groundwater, geotechnical and environmental reports to characterise the geological and hydrogeological setting of the Project.*
- *Review publicly available hydrogeological data such as the Queensland Government's spatial data system (Queensland Globe) and the Bureau of Meteorology's (BoM) National Groundwater Information System (NGIS) (BoM, 2019).*
- *Review the existing census of groundwater supply bores in the vicinity of the Project to confirm locations, usage and groundwater quality.*
- *Characterise the existing groundwater resources, including properties and quality.*
- *Conceptualise the groundwater regime of the Project Area and Study Area.*
- *Assess the potential interaction between the Isaac River and associated alluvium and the Project.*
- *Construction and calibration of a numerical groundwater flow model suitable for the assessment of potential impacts of the Project, in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and Murray Darling Basin Commission guidelines (Middlemis et al., 2001).*
- *Perform predictive modelling for the scale and extent of mining impacts upon groundwater levels, groundwater quality and groundwater users at various stages during mine operations and post-mining.*
- *Predictive modelling of the cumulative impacts of Project, surrounding mines and the other relevant developments (e.g. Bowen Gas Project).*
- *Assess the extent of groundwater impacts as a result of the Project, including long-term impacts on regional groundwater levels and water quality impacts on environmental flows and baseflows.*
- *Assess potential impacts on groundwater dependant ecosystems (GDEs) resulting from short and/or long-term changes in the quantity and quality of groundwater.*

- *Assess the potential third party impacts (i.e. privately-owned bores) as a result of changes to the regional groundwater system.*
- *Develop reasonable and practicable mitigation and management strategies where potential adverse impacts are identified.*
- *Develop a groundwater monitoring program and management measures."*

The groundwater modelling has been conducted to a very high standard and a rigorous *monte carlo* uncertainty analysis offsets much of the uncertainty that is inherent in a groundwater model, as noted in the Limitations Section 9 of Document #1.

The primary output of the uncertainty analysis, with respect to potential off-site impacts, is presented in Document #2 in Figures 5-8 and 5-9 as 10%, 50% and 90% probabilities of exceeding 1 m drawdown in Layer 1 (alluvium and regolith) and Layer 7 (Vermont Seam).



Dr Noel Merrick

Table 1. Model Review (Part A)

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
1.0	THE REPORT								**A: Main Report & B: Appendix B**
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very Good			A: Agency requirements: Section 1.1, Section 6.1.1.
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes				A: Section 6.1.4: Class 2. IESC-format tabulation not included.
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very Good			B: Section 2.6.2: Steady-state calibration. B: Section 2.7.2: Transient calibration. B: Section 3.2: Prediction.
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very Good			Addressed objectives.
1.5	Are the model results of any practical use?			No	Maybe	Yes			Addressed objectives.
2.0	DATA ANALYSIS								
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very Good			Geology maps and cross-sections. Alluvium definition (AgTEM and DC surveys, slope break analysis, SDSG mapping, CSIRO regolith, LiDAR, bore logs). Alluvium saturated thickness map (Fig.5-7). Structure contours and thickness maps for alluvium/regolith, Triassic, Leichhardt Seam, Vermont Seam. Packer tests + slug tests + core lab (Figs.5-3, 5-4). Packer tests in two faults: ~1E-4 to ~1E-3 m/d (Kx). Water quality Piper diagrams. Groundwater salinity map (Fig.5-22).
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very Good			Alluvium (Fig.5-8) and Rangal Coal Measures (Fig.5-12).

2.3	Have all potential recharge data been collected and analysed? (rainfall, streamflow, irrigation, floods, etc.)		Missing	Deficient	Adequate	Very Good			SILO rainfall. Streamflow presented in graphical form for Isaac River, paired with groundwater hydrographs to demonstrate losing conditions.
2.4	Have all potential discharge data been collected and analysed? (abstraction, evapotranspiration, drainage, springflow, etc.)		Missing	Deficient	Adequate	Very Good			Minor private use of groundwater (83 registered water supply bores). 131 bores in bore census (47 in use). Potential GDE map, BoM atlas (Fig.5-25); stygofauna sampling. Leachate analysis for waste rock and rejects.
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very Good			CRD comparison. Separate hydrographs for alluvium, regolith, Rewan, Permian. Evident mining effects at neighbouring mines: Appendix A (Doc.B). Weak sw/gw connectivity.
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes			14 Project monitoring sites including 2 VWP bores; baseline measurements 2019-2020. Neighbouring mine monitoring networks: 44 standpipes and 5 VWP bores. Appendix A (Doc.B). 98 calibration hydrographs.
2.7	Have consistent data units and standard geometrical datums been used?			No	Yes				
3.0	CONCEPTUALISATION								
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes			
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very Good			A: Section 5.7.
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very Good			A: Figures 5-26, 5-27, 5-28 pre-mining, during-mining and post-mining.
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No				

4.0	MODEL DESIGN								Several prior models (ODS, Moorvale)
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes			~50-65km (E-W) x ~70km (N-S). 14 layers. Max 73k cells/layer (less pinchouts). Total 0.79 million cells. Minimum cell size 50m. 100m cells in pits. Many neighbouring mines included.
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very Good			Justified in Section B2.4.1.
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes			MF-USG unstructured + AlgoMesh Voronoi cells.

Table 2. Model Review (Part B)

Q.	QUESTION	Not Applicable or Unknown	Score 0	Score 1	Score 3	Score 5	Score	Max. Score (0, 3, 5)	COMMENT
5.0	CALIBRATION								Steady-state <2006. Transient Jan.2006 – Dec.2019 (14 years).
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very Good			PEST & manual calibration. Steady-state: 177 target water levels. Transient: 18,981 targets at 174 monitoring sites - good spread (x,y,z) (Fig.B2-7). Two scattergrams; residuals (x,y) map; residuals table (App.A); hydrographs (App.B).
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very Good			Scattergrams generally linear across a wide range (~100m).
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very Good			57 quarterly stress periods from 2006. No systematic bias. Doc.B, Appendix A: generally good match to absolute levels; most trends are replicated; some external mining effects are not captured.
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes			Seven separate K(z) depth functions: consistent with field K bandwidth (Figs.B2-8, 2-9). Specific Yield (Sy) generally <1% in Permian and 5% alluvium and waste rock. Specific storage is reasonable (insensitive anyway). Seven diffuse rainfall recharge zones: <0.01% to 0.8% of rainfall.
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Steady-state: 6.7 %RMS, 6.9 mRMS. Transient: 5.2 %RMS, 5.8 mRMS.
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very Good			Mining complexity; incomplete knowledge of external mine plans; potential compartmentalisation due to structural faults; some thick layers (assumed single head).
6.0	VERIFICATION								Optional step for limited data

6.1	Is there sufficient evidence provided for model verification?	N/A	Missing	Deficient	Adequate	Very Good			
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?	N/A	Unknown	No	Maybe	Yes			
6.3	Are there good reasons for an unsatisfactory verification?	N/A	Missing	Deficient	Adequate	Very Good			
7.0	PREDICTION								2020-2053 (34 years). Monthly 2020, annual thereafter. Recovery 250 years.
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very Good			Long-term average during base case prediction and recovery models. Climate variability is accommodated through uncertainty analysis on rainfall recharge.
7.2	Have multiple scenarios been run for operational /management alternatives?		Missing	Deficient	Adequate	Very Good			Single mine plan - normal practice. Two-step recovery model: (1) high-K lake; (2) CHD(t) using surface-water modelled evolution of pit lake levels.
7.3	Is the time horizon for prediction comparable with the length of the calibration / verification period?		Missing	No	Maybe	Yes			Calib: 14 yrs, Pred:34yrs. Ratio Pred/Calib = 2.4
7.4	Are the model predictions plausible?			No	Maybe	Yes			Consistency with neighbouring groundwater assessments.
8.0	SENSITIVITY ANALYSIS								Identifiability approach for calibration. Sensitivity derivatives for prediction.
8.1	Is the sensitivity analysis sufficiently intensive for key parameters?		Missing	Deficient	Adequate	Very Good			Good identifiability analysis. Figs.5-1 to 5-4: Kx, Kz/Kx, Sy, RCH. Many important Kx strata: faults generally poorly identified. Only three important anisotropies: faults poorly identified. Only alluvium is important for Sy. Four important recharge zones.
8.2	Are sensitivity results used to qualify the reliability of model calibration?	N/A	Missing	Deficient	Adequate	Very Good			Not possible with identifiability approach.

8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			Sensitivity derivatives for drawdown extents, alluvial drawdown magnitude, and pit inflows identify the critical parameters in each case.
9.0	UNCERTAINTY ANALYSIS								
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Maybe	Yes			Substantial work. Tables 5-1 to 5-4 (distribution means): Median Kx/Kz is 50. Median Kx is 0.0013 m/day. Median Sy is 0.21% Median RCH is 0.14% - all sensible. Good use of constraints. IESC-compliant Type 3 analysis – *Monte Carlo.* 1400 realisations (Kx, Kz, Sy, Ss, RCH). Distribution functions in Appendix E: some Sy values are not sufficiently constrained (>1).
9.2	Are uncertainty results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very Good			18% calibrated (257 of 1400). Acceptability statistic is 6 %RMS (15% above base case). Evidence is provided for sufficient convergence [a requirement of IESC Explanatory Note] for several outputs of interest: Pit inflows; alluvial take; alluvial drawdown; area of drawdown impact;
9.3	Are uncertainty results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very Good			Doc.B: Figs.5-8 & 5-9 show maps for 10%,50% & 90% probabilities of exceeding 1m drawdown in Layers 1 and 7 (Vermont Seam). Fig.5-5 shows time-series pit inflow for base case, 5th, 50th and 95th percentiles.
NEW	As required by IESC, is qualitative uncertainty summarised?		Missing	Deficient	Adequate	Very Good			Doc.B: Section 6: Limitations.
	TOTAL SCORE								PERFORMANCE: %

HYDRO ENGINEERING & CONSULTING PTY LTD

22 June 2021

Approvals Manager
Whitehaven Coal Limited
GPO Box 3224
Brisbane QLD 4000
Attention: Brendan Dillon

Brendan,

Re: Winchester South Project EIS – Surface Water and Flooding Assessment Peer Review

I have reviewed and commented on the Surface Water and Flooding Assessment (SW&FA) for the Winchester South Project (the Project) Environmental Impact Statement (EIS) prepared by WRM Water & Environment Pty Ltd. This included progressive review of draft versions of the SW&FA report up to and including version B10 of the report dated 20th May 2021.

In undertaking the review I have checked that the SW&FA report addresses the surface water resources related requirements for information, analysis and assessment set out in the Terms of reference for an environmental impact statement – Winchester South Project issued by the Coordinator General on 4th September 2019[1]. These are summarised in Section 1.3 of the SW&FA report.

Through the peer review process I have made a number of requests for clarification and suggestions for modifications to the methodology and reporting. The majority of these were resolved to my satisfaction. It is concluded that the assessment as it stands is sufficient and fit for purpose for the EIS, in terms of the assessment of surface water-related impacts, as it has:

- adequately described the existing surface water environment in the vicinity of the Project, and the relevant environmental values;
- developed and described a proposed operational water management system and demonstrated through modelling that such a system is predicted to operate adequately under a range of climatic scenarios; and
- assessed the potential impacts on relevant environmental values due to the development of the Project.

[1] Department of State Development Manufacturing, Infrastructure and Planning (2019). "Terms of reference for an environmental impact statement: Winchester South Project". Queensland Government Coordinator General, September.

During the review of the project water balance modelling, it was noted that a number of assumptions and considerations were made (with justification, appropriate to an EIS-level assessment), however it is recommended that further analysis be conducted during subsequent studies or detailed design to refine the design of the water management infrastructure. In summary, the recommendations for further analysis and details were as follows:

- detail design of sizing and placement of sediment dams, given that the location and number of sediment dams provided in the assessment are conceptual only;

- continued collection of site-specific baseline surface water quality information prior to Project commencement;

- further design of final landform drainage including the design of long-term stable drainage;

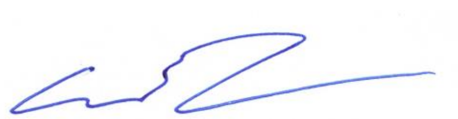
- details of the contaminated water system to collect, contain and recycle all potentially contaminated water (which includes runoff from areas containing explosives, hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods, as well as flammable and combustible liquids) on site; and

- revision of Isaac River hydrologic modelling, to refine flood levee design prior to construction, using all available regional rainfall data (e.g. data available from regional councils) for model calibration.

Notwithstanding the above, this further analysis is considered unlikely to significantly affect the modelling outcomes/conclusions and the assessment of potential impacts already described in the SW&FA.

Please contact the undersigned if you require further information.

Yours faithfully,



Tony Marszalek
Director